

Epidemiology of Foot and Ankle Injuries in National Collegiate Athletic Association Men's and Women's Ice Hockey

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Background: Ice hockey is a high-speed contact sport in which athletes are prone to many different injuries. While past studies have examined overall injury rates in ice hockey, foot and ankle injuries among collegiate ice hockey players have yet to be analyzed.

Purpose/Hypothesis: The purpose of this study was to elucidate the epidemiology of foot and ankle injuries among collegiate ice hockey players utilizing data from the National Collegiate Athletic Association (NCAA) Injury Surveillance Program. We hypothesized that male ice hockey players would sustain more injuries compared with female ice hockey players and that the injuries sustained would be more severe.

Study Design: Descriptive epidemiology study.

Methods: Data on all foot and ankle injuries sustained during the academic years 2004 through 2014 were obtained from the NCAA Injury Surveillance Program. Injury rates, rate ratios (RRs), and injury proportion ratios were reported with 95% CIs.

Results: Over the study period, the overall rate of foot and ankle injuries for men was higher than that for women (413 vs 103 injuries, respectively; RR, 4.01 [95% CI, 3.23-4.97]). Injury rates were highest during the regular season for both men (358 injuries; RR, 64.78 [95% CI, 58.07-71.49]) and women (89 injuries; RR, 38.37 [95% CI, 30.40-46.35]) compared with the preseason or postseason. The most common injury in men was a foot and/or toe contusion (22.5%), while women most commonly sustained a low ankle sprain (31.1%). For men, foot and/or toe contusions accounted for the most non-time loss (≤ 24 hours) and moderate time-loss (2-13 days) injuries, while high ankle sprains accounted for the most severe time-loss (≥ 14 days) injuries. For women, foot and/or toe contusions accounted for the most non-time loss injuries, low ankle sprains accounted for the most moderate time-loss injuries, and high ankle sprains accounted for the most severe time-loss injuries.

Conclusion: Foot and ankle injuries were frequent among collegiate ice hockey players during the period studied. For men, contusions were the most commonly diagnosed injury, although high ankle sprains resulted in the most significant time lost. For women, low ankle sprains were the most common and resulted in the most moderate time lost. These findings may direct future injury prevention and guide improvements in ice skate design.

Keywords: ice hockey; foot and ankle injuries; high ankle sprain; low ankle sprain

Ice hockey is a fast-paced collision sport, played with aluminum sticks and razor-sharp ice skates on a sheet of ice, surrounded by high-density polyethylene boards.¹⁴ There are intrinsic hazards to playing this exciting sport, and it comes as no surprise that ice hockey has one of the highest injury rates in collegiate athletics.²⁹ Despite the injury risk, the popularity of the sport continues to grow, as currently

there are over 7000 National Collegiate Athletic Association (NCAA) varsity ice hockey athletes participating among 168 American colleges and universities.²⁴ Lower extremity injuries are extremely common, with foot and ankle injuries being among the most prevalent.^{2-4,10} For example, prior epidemiology studies have noted that in men's ice hockey, foot and ankle injuries represent approximately 12% of all injuries, with ankle sprains being the fourth most common injury overall.^{3,10,37} Similar studies of women's ice hockey have found that foot and ankle injuries comprise 13% of all injuries, with ankle sprains being

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the third most common injury overall.^{2-4,38} Another investigation of ice hockey injuries noted that ankle sprains caused significant time loss away from the rink, the second most of all studied injuries.³³

While the above studies have highlighted both the prevalence of ankle sprains in ice hockey and their importance with regard to time lost from play and potential long-term side effects, they have failed to fully elucidate these injuries.^{10,22,30} Most importantly, these investigations did not differentiate between low and high ankle sprains, which is a key distinction given the increased severity associated with high ankle sprains. Although there have been prior epidemiological studies examining the overall injury rates in ice hockey, an in-depth analysis of foot and ankle injuries has yet to be performed.^{2-4,12,15,17,18,24} Such a comparison is necessary, as there are key differences between men's and women's hockey, namely that men are allowed to make physical contact with the trunk of their body to separate the opponent from the puck in the form of a body check.^{24,28} However, in women's hockey, checking is illegal, resulting in a 2-minute penalty.²⁸ Past studies have recognized that the overall lower rate of injuries in women's hockey (9.19 per 1000 athlete-exposures [AEs] for men vs 7.77 per 1000 AEs for women) is partially because of the differences in body checking rules.^{1,33}

The goal of this study was to describe the epidemiology of foot and ankle injuries among male and female collegiate ice hockey players. We hypothesized that male ice hockey players would sustain a greater number and have more severe foot and ankle injuries than their female counterparts. The reasoning for this was 2-fold: as a result of differences in body-checking rules and the fact that male players are, on average, larger and may produce greater force.^{16,24} We also hypothesized that the most common foot and ankle injury sustained by ice hockey players would be a high ankle sprain due to the rigid skate boot, thought to be protective against low ankle sprains.²⁵

METHODS

This study analyzed foot and ankle injury data from the NCAA Injury Surveillance Program (NCAA-ISP) collected between 2004 and 2014 for men's and women's ice hockey. In-depth information describing the methods of the NCAA-ISP has been previously described^{14,18,24} and is noted below. The data were based on participating teams in the NCAA-ISP and were not expanded to include all programs.

Data Collection

The NCAA-ISP is an independent, nonprofit research organization that collects athlete injury information. Data were collected by athletic trainers (ATs) who completed standardized electronic forms for all athletes injured during official intercollegiate practices and games. This form includes detailed information regarding the injury (diagnosis, location, type, time loss) and how it occurred (practice/game, mechanism, activity).²⁴ ATs also submitted weekly exposure reports describing participation information such as the number of participating athletes and the number of practices and games. ATs were able to review and update their surveys throughout the season. Information submitted to the NCAA-ISP was evaluated by quality control staff who either verified valid data or identified invalid data.

Between 2004 and 2009, an average of 14.1% of qualified men's ice hockey teams (19/135 programs) and 12.7% of qualified women's ice hockey teams (10/79 programs) participated in data collection. Between 2009 and 2014, an average of 13.2% of qualified men's ice hockey teams (18/136 programs) and 10.6% of qualified women's ice hockey teams (9/85 programs) participated in data collection.¹⁷

Definitions used in this study are as follows. A reportable injury was defined as an injury sustained during either a practice or a competition and required an examination from a medical professional. An AE was defined as 1 student-athlete being exposed to the opportunity of an injury while participating in an official practice or competition. Time loss was defined as the time from when the injury was sustained to when the athlete returned to participation.¹⁷ In line with previous studies, an injury necessitating ≤ 24 hours of restricted activity was defined as a non-time loss (NTL) injury, with a moderate time-loss injury requiring between 2 and 13 days lost from athletic participation and a severe injury defined as restriction of participation for ≥ 14 days or an injury requiring surgery.²⁴

RESULTS

Overall Injury Frequency and Rates

Men's Ice Hockey. In total, 413 foot and ankle injuries were sustained among 552,623 AEs for men's ice hockey between the academic years 2004-2005 through 2013-2014. Practice AEs accounted for 76.5% of the overall AEs ($n = 422,794$), but 55.4% of foot and ankle injuries were sustained during a competition ($n = 229$). The competition injury rate was 176.4 per 100,000 AEs compared with the practice injury

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Ethical approval was not sought for the present study.

TABLE 1
Foot and Ankle Injury Rates by Division, Type of AE, and Time of Season for Men's and Women's Ice Hockey^a

	Foot and Ankle Injuries, n			Injury Rate per 100,000 AEs (95% CI)		
	Overall	Competition	Practice	Overall	Competition	Practice
Men's						
Total	413	229	184	74.73 (67.53-81.94)	176.39 (153.56-199.21)	43.52 (37.23-49.81)
Division I	164	94	70	29.68 (25.14-34.22)	72.40 (57.77-87.03)	16.56 (12.68-20.43)
Division II	64	40	24	11.58 (8.74-14.42)	30.81 (21.26-40.36)	5.68 (3.41-7.95)
Division III	185	95	90	33.48 (28.65-38.30)	73.17 (58.46-87.88)	21.29 (16.89-25.68)
Regular season	358	217	141	64.78 (58.07-71.49)	167.14 (144.92-189.36)	33.35 (27.85-38.85)
Postseason	16	8	8	2.90 (1.48-4.31)	6.16 (1.89-10.43)	1.89 (0.58-3.20)
Preseason	39	4	35	7.06 (4.84-9.27)	3.08 (0.06-6.10)	8.28 (5.54-11.02)
Women's						
Total	103	55	48	44.41 (35.84-52.99)	93.19 (68.57-117.81)	27.76 (19.91-35.61)
Division I	29	20	9	12.50 (7.95-17.05)	33.89 (19.04-48.74)	5.21 (1.80-8.61)
Division II	6	5	1	2.59 (0.52-4.66)	8.47 (1.05-15.90)	0.58 (0.00-1.71)
Division III	68	30	38	29.32 (22.35-36.29)	50.83 (32.65-69.02)	21.98 (14.99-28.96)
Regular season	89	54	35	38.37 (30.40-46.35)	91.50 (67.10-115.89)	20.24 (13.54-26.95)
Postseason	4	1	3	1.72 (0.03-3.41)	1.69 (1.63-5.02)	1.74 (0.00-3.70)
Preseason	10	0	10	4.31 (1.64-6.98)	0.00 (—)	5.78 (2.20-9.37)

^aAE, athlete-exposure.

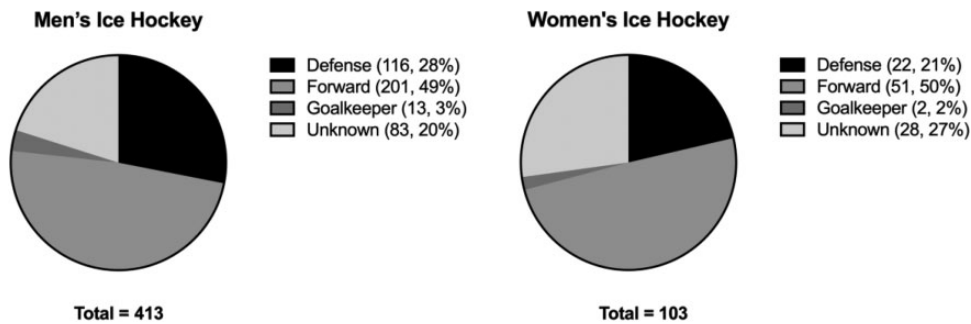


Figure 1. Injury by position for men's and women's ice hockey.

rate of 43.5 per 100,000 AEs. Division III athletes sustained the greatest total number of foot and ankle injuries, accounting for 44.8% of all foot and ankle injuries, and had the greatest overall injury rate of 33.5 per 100,000 AEs. Additionally, 86.7% of foot and ankle injuries occurred during the regular season (n = 358), with the majority occurring during a competition (167.1 per 100,000 AEs) (Table 1).

Male forwards sustained the highest frequency of foot and ankle injuries (48.7%), followed by defensemen (28.1%). As hockey is played with 6 players on the ice per team with 3 forwards, 2 defensemen, and 1 goalie, these injury rates are proportionate to the number of players on the ice. Of note, 20.1% of injuries by position were reported as unknown/not available (Figure 1).

Women's Ice Hockey. In total, 103 foot and ankle injuries were sustained among 231,928 AEs for women's ice hockey. Practice AEs comprised 74.6% of the overall AEs (n = 172,910), but 53.4% of foot and ankle injuries were sustained during a competition (n = 55). The competition injury rate was 93.2 per 100,000 AEs, which was significantly greater than the practice injury rate of 27.8 per 100,000 AEs. Division III athletes

TABLE 2
Injury Rate Ratios by Division and Time of Season for Men's and Women's Ice Hockey

	Men's, n	Women's, n	Rate Ratio (95% CI)
Overall	413	103	4.01 (3.23-4.97)
Division I	164	29	5.66 (3.81-8.39)
Division II	64	6	10.67 (4.61-24.60)
Division III	185	68	2.72 (2.06-3.59)
Regular season	358	89	4.02 (3.19-5.07)
Postseason	16	4	4.00 (1.33-12.00)
Preseason	39	10	3.90 (1.95-7.81)

sustained the greatest total number of foot and ankle injuries, accounting for 66.0% of all foot and ankle injuries, and had the greatest overall injury rate (29.3 per 100,000 AEs). Additionally, 86.4% of foot and ankle injuries occurred during the regular season (n = 89), with the majority occurring during a competition (91.5 per 100,000 AEs) (Table 1).

TABLE 3
Injury Proportion Ratios by Injury Type
for Men's and Women's Ice Hockey

	Men's, n (%)	Women's, n (%)	Injury Proportion Ratio (95% CI)
Abrasion	5 (1.21)	0 (0.00)	—
Bursitis	7 (1.69)	0 (0.00)	—
Contusion (hematoma)	160 (38.74)	35 (33.98)	1.14 (0.85-1.53)
Effusion	1 (0.24)	0 (0.00)	—
Exostosis	2 (0.48)	0 (0.00)	—
Fracture	25 (6.05)	6 (5.83)	1.04 (0.44-2.47)
Impingement	1 (0.24)	0 (0.00)	—
Infection	3 (0.73)	0 (0.00)	—
Inflammation	2 (0.48)	6 (5.83)	0.08 (0.02-0.41)
Laceration	6 (1.45)	1 (0.97)	1.50 (0.18-12.29)
Miscellaneous	12 (2.91)	3 (2.91)	1.00 (0.29-3.47)
Sprain	170 (41.16)	50 (48.54)	0.85 (0.67-1.07)
Strain	3 (0.73)	1 (0.97)	0.75 (0.08-7.12)
Synovitis	16 (3.87)	0 (0.00)	—
Tendinitis	0 (0.00)	1 (0.97)	0.00 (—)

Similar to men's hockey, forwards sustained the highest frequency of foot and ankle injuries (49.5%), followed by defensemen (21.4%) and then goaltenders (2.0%). Of note, 27.2% of injuries by position were reported as unknown/not available (Figure 1).

Sex-Based Differences. The overall rate of foot and ankle injuries in men's ice hockey was noted to be significantly higher than that in women's ice hockey (Table 2). This included injuries sustained during the preseason, regular season, and postseason. Compared with women, men had approximately twice the probability of sustaining foot and ankle injuries during the preseason or postseason. There were no differences between men's and women's ice hockey with regard to foot and ankle injuries by laterality of injury or player position.

Injury Type and Specific Injuries

The most common foot and ankle injury type sustained for both men and women was a sprain (men, 41.2%; women, 48.5%), followed by a contusion (men, 38.7%; women, 34.0%). The third most common injury was a fracture for men (6.1%), while a fracture and inflammation (lace bite) were equally common for women (5.8% for each) (Table 3).

The most common specific foot and ankle injury overall for men was a foot/toe contusion (22.5%), which occurred most often during a practice (Table 4). The second most common injury overall was a low ankle sprain (19.1%), which was the most common injury sustained during a competition, followed closely by a high ankle sprain (17.2%). The most common specific foot and ankle injury overall for women was a low ankle sprain (31.1%), which occurred most often during both competitions and practices (Table 4). The second most common injury sustained during competitions and practices for women was a foot/toe contusion (26.2%).

TABLE 4
Injury Rates by Specific Injury
for Men's and Women's Ice Hockey^a

Men's	n (%)	Women's	n (%)
Overall			
Foot/toe contusion	93 (22.5)	ATFL/CFL/PTFL tear (partial or complete)	32 (31.1)
ATFL/CFL/PTFL tear (partial or complete)	79 (19.1)	Foot/toe contusion	27 (26.2)
High ankle sprain (partial or complete)	71 (17.2)	High ankle sprain (partial or complete)	11 (10.7)
Ankle contusion	67 (16.2)	Ankle contusion	8 (7.8)
Ankle synovitis	16 (3.9)	Plantar fasciitis	5 (4.9)
Competition			
ATFL/CFL/PTFL tear (partial or complete)	55 (24.0)	ATFL/CFL/PTFL tear (partial or complete)	18 (32.7)
High ankle sprain (partial or complete)	45 (19.7)	Foot/toe contusion	15 (27.3)
Foot/toe contusion	42 (18.3)	High ankle sprain (partial or complete)	7 (12.7)
Ankle contusion	39 (17.0)	Ankle contusion	4 (7.3)
Deltoid ligament tear (partial or complete)	8 (3.5)	Plantar fasciitis	2 (3.6)
Practice			
Foot/toe contusion	51 (27.7)	ATFL/CFL/PTFL tear (partial or complete)	14 (29.2)
Ankle contusion	28 (15.2)	Foot/toe contusion	12 (25.0)
High ankle sprain (partial or complete)	26 (14.1)	High ankle sprain (partial or complete)	4 (8.3)
ATFL/CFL/PTFL tear (partial or complete)	24 (13.0)	Ankle contusion	4 (8.3)
Ankle synovitis	10 (5.4)	Plantar fasciitis	3 (6.3)

^aATFL, anterior talofibular ligament; CFL, calcaneofibular ligament; PTFL, posterior talofibular ligament.

Injury Mechanism

For men and women, the most frequent mechanism of injury was contact with an apparatus (men, 51.8%; women, 44.7%), which may have included contact with the boards or glass, the goal, or another player's stick. The second most common mechanism of injury included contact with a player for men (18.6%) and acute noncontact for women (22.3%) (Table 5).

Time Loss and Surgery

NL injuries (≤ 24 hours) accounted for the majority of foot and ankle injuries for men (41.4%) and women (49.5%) (Figure 2). The overall rate of NTL injuries was 31.0 per 100,000 AEs for men versus 22.0 for women. Injuries requiring surgery, NTL injuries, moderate injuries, and severe injuries occurred most often during the regular season for men and women (NTL: n = 171 for men vs 51 for women). The most common NTL injury diagnoses for men

TABLE 5
Injury Proportion Ratios by Mechanism of Injury
for Men's and Women's Ice Hockey

	Men's, n (%)	Women's, n (%)	Injury Proportion Ratio (95% CI)
Acute noncontact	50 (12.1)	23 (22.3)	0.54 (0.35-0.85)
Contact with apparatus	214 (51.8)	46 (44.7)	1.16 (0.92-1.47)
Contact with out-of- bounds object	1 (0.2)	0 (0.0)	—
Contact with person	77 (18.6)	14 (13.6)	1.37 (0.81-2.32)
Contact with surface	27 (6.5)	9 (8.7)	0.75 (0.36-1.54)
Illness	4 (1.0)	0 (0.0)	—
Overuse/gradual	29 (7.0)	6 (5.8)	1.21 (0.51-2.83)
Other/unknown	11 (2.7)	5 (4.9)	0.55 (0.19-1.54)

and women were contusions, inflammation, and lacerations (Table 6).

Severe injuries (≥ 14 days) were the least common for both men (19.6%) and women (13.6%). The rate of severe injuries was 14.7 per 100,000 AEs for men versus 6.0 for women, while the rate of injuries requiring surgery was 1.6 per 100,000 AEs for men ($n = 6$) and 0.0 for women ($n = 0$). Overall, in men's ice hockey, foot injuries and ankle injuries accounted for 1.7% and 0.8% of all surgeries, respectively. In women's ice hockey, foot and ankle injuries did not account for any surgeries.

For men, high ankle sprains accounted for the most severe time-loss (≥ 14 days) injuries (Figure 3). For women, low ankle sprains accounted for the most moderate time-loss (2-13 days), but high ankle sprains accounted for the most severe time-loss (≥ 14 days) injuries (Figure 4). Overall, 47.6% of high ankle sprains led to NTL, 32.9% led to moderate time loss, and 19.5% led to severe time loss. For low ankle sprains, 17.1% led to NTL, 53.2% led to moderate time loss, and 29.7% led to severe time loss.

DISCUSSION

Contact athletes are prone to injuries of the lower extremities.¹⁴ For example, in an epidemiological study of collegiate injuries across 15 sports, Hootman et al¹² found that 58% of game injuries and 41.6% of practice injuries were contact related, with more than half of all injuries being to the lower extremity. Of these injuries, the authors found that ankle ligament sprains were among the most common injuries across all sports (14.8%).¹² Hockey, in particular, is a collision sport that has recently garnered significant attention among injury epidemiology investigations. Past studies have specifically examined sex-based differences in head injuries, inclusive of concussions, as well as injuries of the upper extremity among collegiate ice hockey athletes.^{6,7,24,40} A study looking at the same data of NCAA hockey players, but focusing on hip and groin injuries, found that these injury rates were greater in men's than in women's ice hockey.⁸ The current investigation analyzed the rates of foot and ankle

injuries between men's and women's ice hockey and has a few key findings worth discussing.

First, the overall rate of foot and ankle injuries was higher for men than for women over the 10-year period examined, with men sustaining approximately 4 times as many injuries as women. While men (51.8%) and women (44.7%) both sustained most lower extremity injuries from contact with an apparatus (boards, a player's stick, and the goal), men sustained a greater proportion of injuries from contact with another player (18.6% vs 13.6%, respectively), while women had a higher proportion of acute noncontact injuries (22.3% vs 12.1%, respectively). Interestingly, a study by Melvin et al²⁴ found that the most common cause of injury to the upper extremity among hockey players was also contact with an apparatus (41.6%). However, a much greater proportion of upper extremity injuries were caused by contact with a player for both men and women, 38.3% and 24.9%, respectively, compared with lower extremity injuries.²⁴ A 2018 epidemiological study of ankle injuries in male and female collegiate basketball athletes noted similar results to our study.³⁶ Men were found to sustain a higher rate of ankle injuries compared with women, and women were also found to sustain a higher rate of injuries from acute noncontact mechanisms and a lower rate of contact injuries compared with men, which the authors postulated was caused by differences in playing styles and physical attributes.³⁶ In contrast, they found the most common mechanism for an ankle injury to be contact with another player, with 57.6% and 50.4% of ankle injuries in men and women, respectively, being caused by player contact.³⁶

As was initially hypothesized, the differences in the frequency and mechanisms of lower extremity injuries identified between sexes were likely because of a combination of rule differences (body checking) as well as intrinsic sex-based differences such as height, weight, and strength that would have resulted in greater momentum and force during collisions with other players, the ice, or the boards.^{36,41} However, it is important to note that contact with a person still resulted in 13.6% of female lower extremity injuries. Thus, although checking is illegal in women's ice hockey, incidental contact does occur and can be a significant source of injuries.⁶

The differences noted in these mechanisms of injury, as well as the more aggressive playing style inherent in men's hockey, likely influenced the types and severity of injuries. Overall, male collegiate ice hockey players were found to have greater rates of NTL injuries, severe injuries, and surgery for foot and ankle injuries compared with female collegiate ice hockey players.

The majority of foot and ankle injuries diagnosed in this investigation were classified as NTL injuries. The most common NTL injury diagnosed for both men and women was a contusion, comprising 38.7% and 34.0%, respectively, of all injuries. Foot/toe contusions were most common for both sexes, representing 22.5% of male injuries and 26.2% of female injuries. Ankle contusions were less common. Sprains accounted for the second most common types of injury in both men and women. When comparing low with high ankle sprains in women,

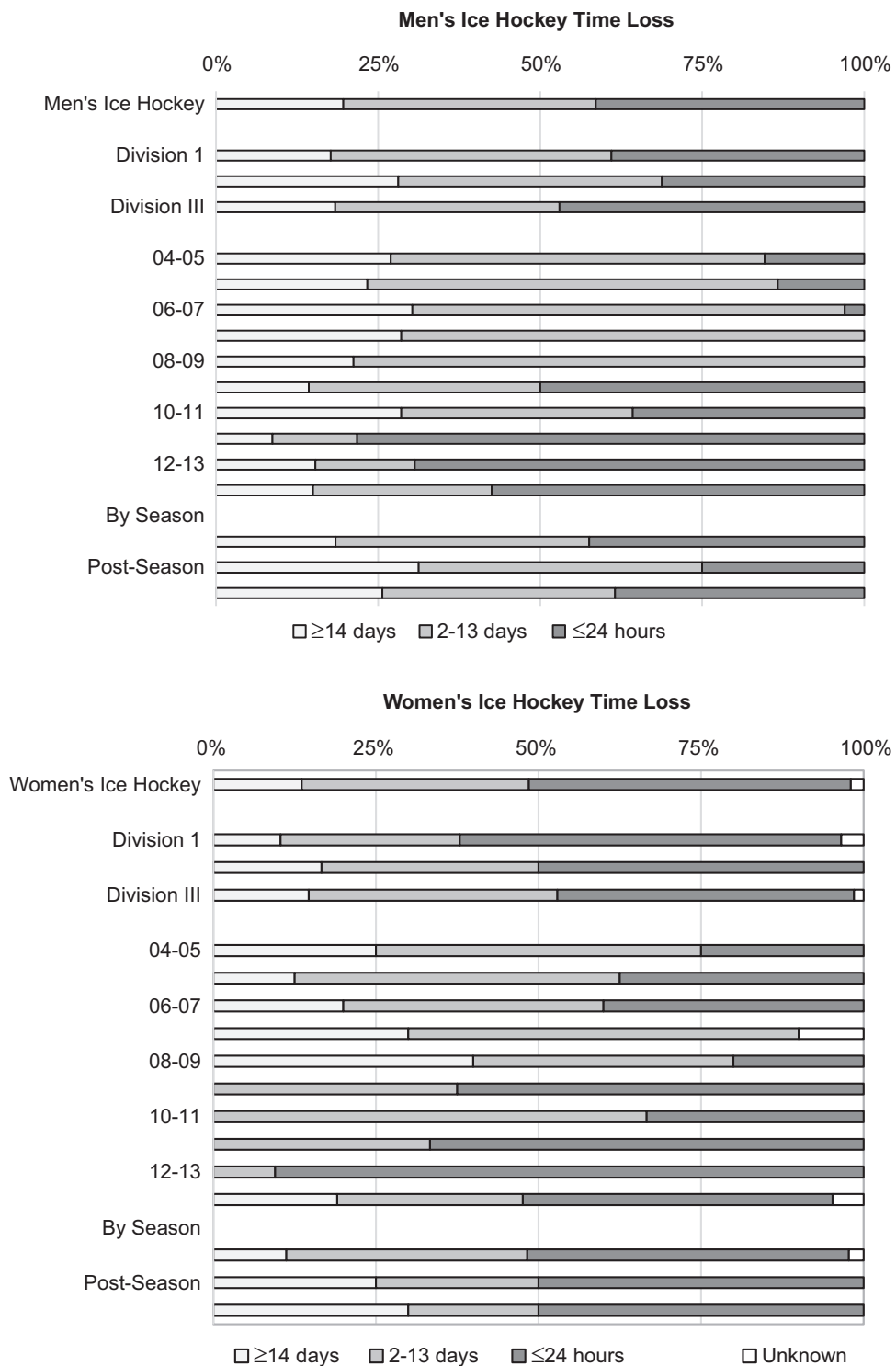


Figure 2. Injury time loss for men's and women's ice hockey.

there was a near 3:1 ratio versus a near 1:1 ratio in men. Additionally, high ankle sprains accounted for the majority of injuries that resulted in time loss of 2 to 13 days or ≥ 14 days. For women, low ankle sprains accounted for most of the women's injuries that resulted in time loss of

2 to 13 days. High ankle sprains in women resulted in the majority of severe time loss injuries.

Our study noted that 49.3% and 36.3% of high ankle sprains in men and women, respectively, resulted in time loss of ≥ 14 days. In comparison, a recent NCAA basketball

TABLE 6
Injury Rates by Diagnosis
for Men's and Women's Ice Hockey^a

	Injuries, n	Injury Rate per 100,000 AEs	Non- Time Loss Injury, %	Severe Injury, %	Injury Requiring Surgery, %
Men's	413	74.73			
Abrasion	5	0.90	100.0	0.0	0.0
Bursitis	7	1.27	100.0	0.0	0.0
Contusion (hematoma)	160	28.95	53.1	3.1	0.0
Effusion	1	0.18	100.0	0.0	0.0
Exostosis	2	0.36	50.0	0.0	0.0
Fracture	25	4.52	16.0	76.0	4.0
Impingement	1	0.18	0.0	0.0	0.0
Infection	3	0.54	33.3	33.3	0.0
Inflammation	2	0.36	0.0	0.0	50.0
Laceration	6	1.09	33.3	16.7	33.3
Miscellaneous	12	2.17	50.0	8.3	8.3
Sprain	170	30.76	24.7	31.8	0.6
Strain	3	0.54	66.6	0.0	0.0
Synovitis	16	2.90	93.8	0.0	0.0
Women's	103	44.41			
Contusion (hematoma)	35	15.09	62.9	5.7	0.0
Fracture	6	2.59	16.7	33.3	0.0
Inflammation	6	2.59	100.0	0.0	0.0
Laceration	1	0.43	100.0	0.0	0.0
Miscellaneous	3	1.29	66.7	33.3	0.0
Sprain	50	21.56	36.0	18.0	0.0
Strain	1	0.43	0.0	0.0	0.0
Tendinitis	1	0.43	100.0	0.0	0.0

^aAE, athlete-exposure.

study found that 22.0% and 16.4% of high ankle sprains in men and women, respectively, resulted in time loss of greater than 14 days.³⁶ Possible long-term sequelae of high ankle sprains include recurrent injuries, persistent ankle instability, heterotopic bone formation, and posttraumatic osteoarthritis.^{11,26,34} A 2017 study by Mauntel et al²² examined high ankle sprains across all NCAA sports and found ice hockey to have the highest rate of high ankle sprains (1.19 per 10,000 AEs). Flik et al¹⁰ found that high ankle sprains caused the longest average time loss in men's ice hockey, with a mean of 5.4 games and 14.6 practices missed. In terms of recovery, it has been suggested that high ankle sprains can take between 6 and 12 weeks to heal in ice hockey players.^{13,20} Porter et al³⁰ examined the optimal management of ankle syndesmosis injuries across all sports and recommended returning to sport 4 to 8 weeks for grade I ankle syndesmosis injuries and surgical treatment for grade II and III injuries. The conservative protocol suggested by Porter et al³⁰ was not observed among collegiate hockey players in the current investigation, as more than half of athletes with high ankle sprains were able to return to play within 2 weeks of injury. Furthermore, across all NCAA sports, it has been found that approximately half of the high ankle sprains sustained by collegiate athletes

resulted in 7 days of missed sport participation, with nearly 1 in 6 athletes missing 21 days.²²

Syndesmosis injuries are also reported in professional ice hockey players. One study across 2 National Hockey League franchises found that approximately 3 of 4 ankle sprains were syndesmosis sprains, requiring an average recovery time of 45 days.¹⁹ The authors explained that the ankle is at high risk for torque injuries, often caused by "catching a rut," because of the combination of elevation on skates, high speeds, and rapid directional changes. They also reported that while the stiff hockey boot provides ankle stability, it also places the area just proximal to the boot at a high risk for injuries.¹⁹

A low ankle sprain was found by Roos et al³² to be the most common overall injury in NCAA athletics, making up 7.3% of all reported injuries. These authors also found that 3.6% of sprains required ≥ 21 days to return to play.³² Our study noted that 17.7% and 15.6% of low ankle sprains in men and women, respectively, resulted in time loss of ≥ 14 days; in comparison, a recent NCAA basketball study found that 16.4% and 15.5% of low ankle sprains in men and women, respectively, resulted in time loss of greater than 14 days.³⁶ In ice hockey, minor and moderate low sprains are commonly managed with rehabilitation, allowing athletes to return to play within a few days to a week, as ice hockey skates provide some intrinsic support and protection.²⁰

Past studies have demonstrated that sports associated with player contact have a dramatic difference in the practice and game injury rate.¹² Despite practices and games containing the same common apparatus risk factors for an injury, sharp skates, hockey sticks, and high-speed pucks, the increased injury rate in competitions is likely due to the increased player contact compared with practices and due to game intensity.¹² Other authors have noted ankle injuries to be highest in the preseason because of poor athlete conditioning at the start of the season and vigorous training.^{12,36,43} However, this study found the injury rate for both men and women to be significantly higher during the regular season compared with the preseason.

Ankle contusions and sprains as common foot and ankle injuries in ice hockey may direct design changes to the construct of the ice skate to help minimize these injuries moving forward. Interestingly, Agel and Harvey⁴ noted that for the past decade, equipment manufacturers have been strongly marketing lighter equipment, most notably skates. Skates are frequently made lighter by decreasing the amount of material in the front (tongue area) and in the sidewall of the skate, rendering the foot and ankle vulnerable to impact, particularly from a high-velocity puck.^{4,5} There were 6 lacerations involving the ankle area in men and 1 laceration in a female player during the study period. Currently, Kevlar socks can be worn, which have been shown in biomechanical studies to diminish the severity of injuries from a skate blade.¹⁴

From a foot and ankle injury prevention perspective, the results of this study call into question the role of a preseason strengthening program to minimize the incidence of low ankle sprains and screening to identify athletes at risk.³⁶ Poor proprioceptive control, decreased single-leg balance, and a

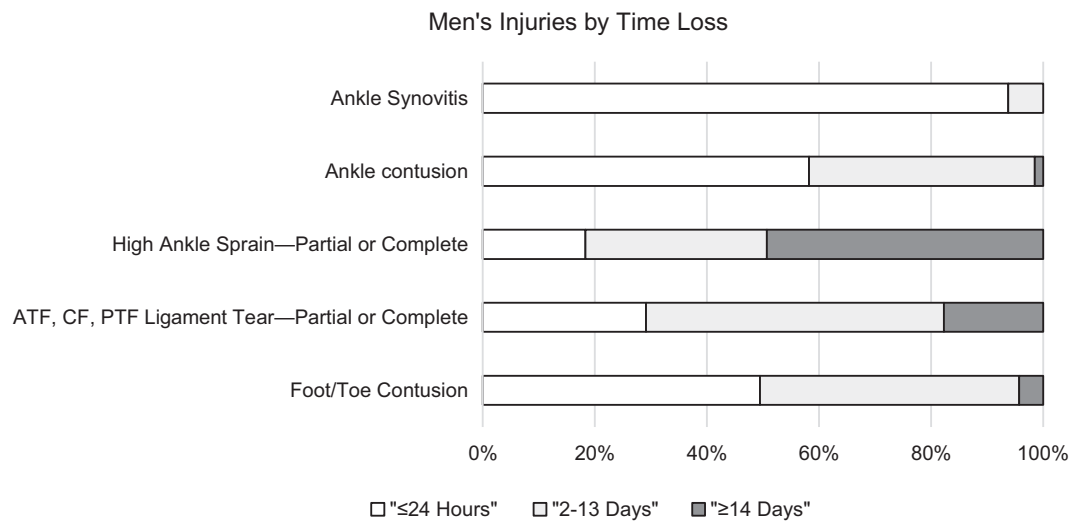


Figure 3. Time loss by specific injury for men's ice hockey. ATF, anterior talofibular; CF, calcaneofibular; PTF, posterior talofibular.

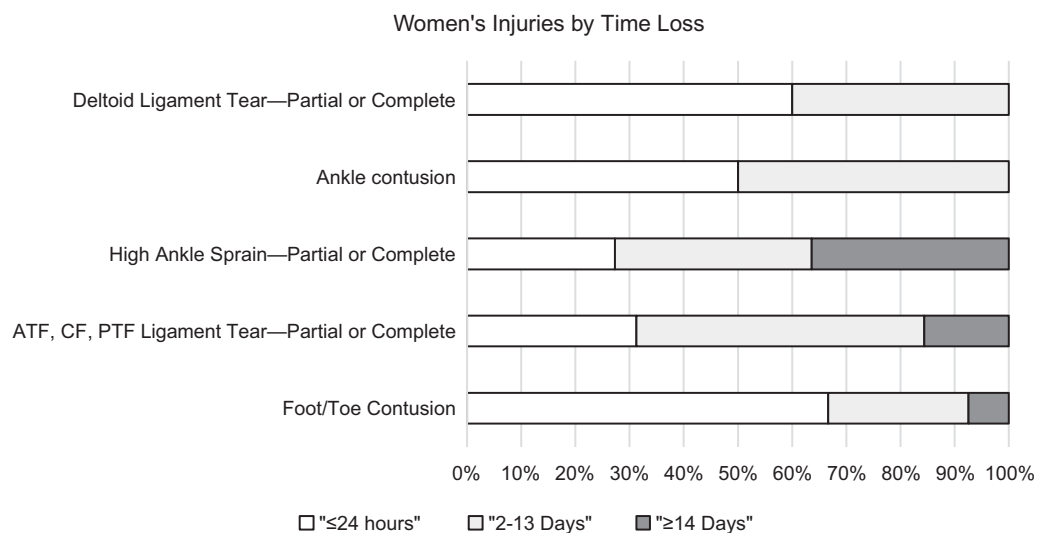


Figure 4. Time loss by specific injury for women's ice hockey. ATF, anterior talofibular; CF, calcaneofibular; PTF, posterior talofibular.

history of ankle sprains have been noted as risk factors for an injury in basketball, the sport with the highest rate of ankle sprains.^{21,23,27,31,36,39} Prophylactic injury prevention programs that focus on improving neuromuscular performance for as little as once per week have been noted to be effective in decreasing ankle sprains.^{9,31,35,36} A recent meta-analysis of ankle injury prevention programs in soccer demonstrated a significant reduction in these injuries.¹¹ Further research is warranted to develop an off-season ice hockey-specific ankle injury prevention program focusing on balance board, proprioceptive training, dynamic stability, and plyometrics.

This study provides a general overview of foot and ankle injuries of NCAA ice hockey athletes. However, there are several limitations. First, this study sample consists only

of NCAA athletes, making the findings less applicable to younger, older, or less skilled players. Second, data collection relied on reporting from multiple different ATs, leading to less standardization and more subjective diagnoses of foot and ankle injuries. Third, the number of foot and ankle injuries analyzed in this study was relatively low, limiting the statistical power in analysis. Fourth, clinical tests for high and low ankle sprains are not very sensitive or specific and often require imaging for a proper diagnosis.⁴² Some injuries may have been missed or misdiagnosed. Last, sprain grading was not reported in the database. This information could provide insight into the connection between injury severity, time loss, and the need for surgery.²⁴

CONCLUSION

The data in our study supported our hypotheses that male ice hockey players would sustain more foot and ankle injuries and more severe injuries than female ice hockey players. The data did not support our hypothesis that the most common foot and ankle injury overall is a high ankle sprain, as foot and toe contusions were the most prevalent, followed by low ankle sprains. The overall rate of foot and ankle injuries was much greater in men compared with women. These data may provide insight for future injury prevention programs and offer suggestions of where to focus improvements in the construction and design of ice hockey skates.

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